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Sizing and Finest Operation of Battery Energy Storage and Control Architecture of Microgrid Power Quality Management System Using S-FACTS

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ABSTRACT: This system presents the use of battery energy storage system for power smoothing in generation systems in which power flow variations can occur. These variations are the model of energy distribution through grid. Today, increase the call for of electrical energy at diverse degree i. E. Industrial, domestic equipment, irrigation and so on. Electrical electricity limited because total energy requirement is furnished with the aid of the burning of fossil fuels and it's far restrained. In this system focused towards a control strategy of three phase four wire grid interfacing inverter to effectively utilize the battery storage Energy at distribution level. Controlling of inverter in such a way that to utilize the following function 1) compensate load current (i.e. reduce harmonics), 2) compensate load voltage (i.e. reduce harmonics), 3) compensate load reactive power and load neutral Current and 4) Improve power quality by using Super FACTS (S-FACTS). The battery storage energy level depends on distribution system voltage level. All these works of the microgrid is done either individually or combined to overcome the unbalanced effects of all types of linear, non-linear, balance or unbalance loads at distribution level. Simulations have been carried out and demonstrate that the BESS has the potential to significantly improve the grid power performance. The process of the battery energy storage system (BESS) is optimal sizing by non-dominated sorting genetic algorithm (NSGA-II). Through control of the charging and discharging of the BESS using a power electronic interface, it is shown that the grid output power can be controlled to a constant value. In addition, there is an overall improvement in the transient and dynamic response of the system.

KEYWORDS: NSGA-II, S-FACT, BESS and power quality improvement

I. INTRODUCTION

In recent years, the use of sustainable power source assets (RESs), for example, wind, solar, and biomass energy, rather than non-renewable energy source assets has obtained more consideration around the world because of the expanding awareness's with respect to issues concerning an unnatural weather change. However, Renewable Energy sources have significantly made discontinuity in power exchange, which influences the stability, efficiency,

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reliability and power quality of power system. Consequently, the idea of micro-grid is regarded as a conceivable answer for the arrangement with these issues. The micro-grid is made out of many little power bases & energy storage system (ESSs), recognized as distributed- energy resources (DERs) to supply power to the neighboring load regions. DERs are associated with micro-grid over power electronic gadgets, for example, power-inverters. The micro-grid can work by associating with the main-grid, which is very well known as the grid-connected mode, or operates autonomously when any type of disturbances and fault happens in the main-grid, which is recognized as islanded-mode.

The system measures and analyses the real strength consumption of the main device devices. When the peak loads appear in system, the EMS ensures turning off the controllable devices, while during periods of low electricity consumption the EMS activates these consumers. To mitigate different types of power quality related issues in the microgrid different controllers are used. Mostly Unified Power Quality Conditioner (UPQC) as compensating device is used. Series VSI mitigate supply side disturbances and shunt VSI mitigate load side disturbances. From literature review the importance of UPQC for mitigating several power quality issues especially towards distribution system are suggested. Here we introduced a new power quality smart device called Distributed Power Flow Controller called D-FACT or S-FACT (Super – FACT). Energy management of different type's consumers is illustrated such as microgrid for local controllers.

The stability of the microgrid is dependent upon the microgrid units' abilities to mitigate and compensate for these phenomena. A BESS can be used to simultaneously exchange active power between the battery and the grid and improve the power quality of a microgrid. With independent cascaded control of currents and active and reactive power, a BESS can control the reactive power balance in a microgrid and therefore ensure voltage stability. In addition, a BESS can serve as an active harmonic filter. Due to the transient nature of the described phenomena, these control schemes require control in real time. All the applications mentioned above can be realized simultaneously with suitable control design where the different controlled quantities are superposed. This paper reviews the technology of a BESS and the required control systems to realize the power quality features and presents simulation results as proof of their feasibility. The simulations demonstrate how a BESS can greatly contribute to microgrid stability while also performing active power exchange.

II. EXISTING SYSTEM

A grid-connected battery energy storage system (BESS) has multiple applications as a grid supporting unit. Most common applications consider the ability of a BESS to decouple electric power generation and consumption in different contexts which is usually desirable from the grid operator point of view. A microgrid consisting of renewable energy sources connected with power electronic converters can experience difficulties with harmonic voltages and reactive inrush currents. Reactive currents may cause a voltage drop in the line impedances.

Voltage fluctuations and harmonics can cause issues such as equipment tripping, overheating and malfunctioning. The stability of the microgrid is dependent upon the microgrid units' abilities to mitigate and compensate for these phenomena. A BESS can be used to simultaneously exchange active power between the battery and the grid and improve the power quality of a microgrid. With independent cascaded control of currents and active and reactive power, a BESS can control the reactive power balance in a microgrid and therefore ensure voltage stability. In addition, a BESS can serve as an active harmonic filter. Due to the transient nature of the described phenomena, these control schemes require control in real time.

Problem Identification

- The power control method is based on reactive compensation technique by using superconducting magnetic Energy storage system (SMES). A **disadvantage** is that the **energy** content of SMES **systems** is small and short-lived, and the cryogenics (cold temperature technology) can be a challenge.
- The machine having an excessive amount of reactive electricity flowing around within the network can cause excess heating (i^2*r losses) and unwanted voltage drops and lack of power along the transmission lines.**SMES** are they have low **energy** density and a high cost per installed **energy**.

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- Besides the harmonics, because of the intermittent nature of DERs, a microgrid can experience active and reactive power fluctuations and voltage and frequency deviations.
- The real **limitation** on the amount of **energy** that can be **stored** in a SMES **system**

III. PROPOSED SYSTEM

In this system focused towards a control strategy of three phase four wire grid interfacing inverter to effectively utilize the battery storage Energy at distribution level. Controlling of inverter in such a way that to utilize the following function 1) compensate load cutting-edge (i.e. reduce harmonics), 2) compensate load voltage (i.e. reduce harmonics), 3) compensate load reactive power and load neutral Current and 4) Improve power quality by using Super FACTS (S-FACTS). The battery storage energy level depends on distribution system voltage level. All these works of the microgrid is done either individually or combined to overcome the unbalanced effects of all types of linear, non-linear, balance or unbalance loads at distribution level. Simulations have been carried out and demonstrate that the BESS has the potential to significantly improve the grid power performance. The process of the battery energy storage system (BESS) is optimal sizing by non-dominated sorting genetic algorithm (NSGA-II). Through control of the charging and discharging of the BESS using a power electronic interface, it is shown that the grid output power can be controlled to a constant value. In addition, there is an overall improvement in the transient and dynamic response of the system.

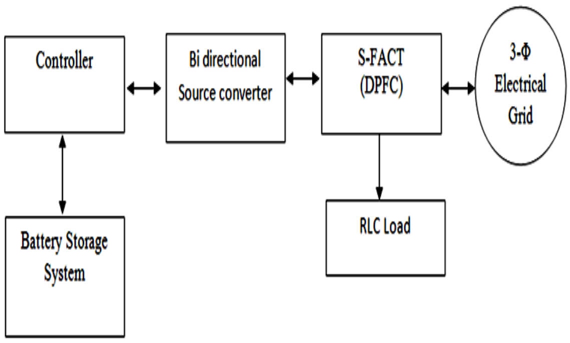

Fig: 1 Functional block diagram

The system consists of Battery Storage system, controller, Bidirectional Source converter, Distributed power flow controller, RLC loads and 3-phase electrical grid. The electrical power from the main grid is the distributed to load through DPFC. The Distributed Power Flow Controller is a smart device also called super fact which is used to smoothing and regulating the power variations due to the non-linear loads. The DPFC is widely used for compensating the power quality issues on the distribute generation system. The grid power also supplied to the battery storage units through DPFC, bidirectional converter and controller.

The bi-directional converter is used to convert the AC into DC for charging the battery units through controller when the grid power is high and excess of demand and it converts the DC into AC for supplying the energy to main grid when the grid power is low or increasing demand level. The controller is used to regulating the power level according to the battery storage capacity and removes the third level harmonics. The controller parameters are designed by using Non-dominated Sorting Genetic Algorithm –II.

IV. BATTERY MANAGEMENT SYSTEM

Figure 2 show a model of battery energy storage system and Fig 3 represents a simple electric battery design (a) and a complex form battery design (b). A battery energy storage system (BESSs) has to represent several key behaviors i.e. voltage, current, capacity, state of charge, impedance and losses.

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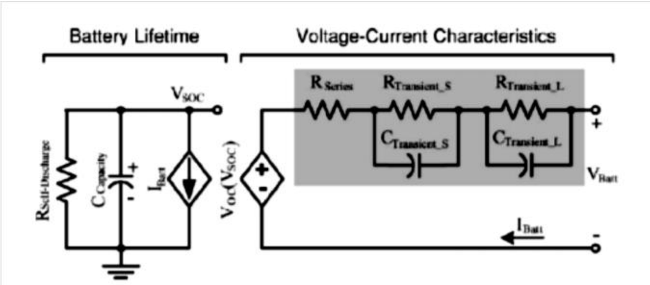

Fig.2 BESS Model

While developing EMS the following considerations are made. The inputs require for EMS are as follows:

- Power generated from PV system (Ppv)
- Power generated by Wind turbine(Pw)
- State of charge of battery (SOC)
- Non controllable load (Pl1)
- Controllable load (Pl2)

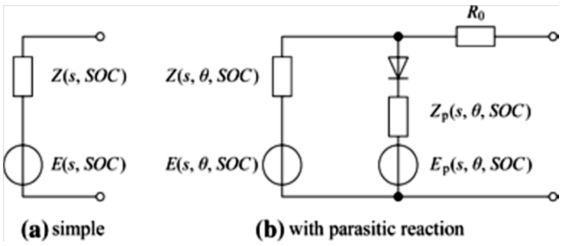

Fig.3 Electric battery design

The output signals are:

- G1 for charging of battery
- G2 for discharging of battery
- G3 for grid on/off
- G4 for load to switch on/off

MATHEMATICAL FORMULATION

The Energy Management System developed is based on following mathematical formulation. Which is depends on the data collected from generation side and connected load side. Energy management System formulation is as follows: Total energy generated from renewable sources is calculated from

Ppv + Pw = PT g (1)
Where, PPV is power generated by PV and PT g is power generated by WTGS and total load is given by,
Pl1 + Pl2 = PT l (2)
where, Pl1 is of non controllable load and Pl2 is controllable load. Total connected load is PTl.
PTg > PT l (3)

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then battery is charged through renewable energy sources by triggering charging controller by giving signal G1 = 1 otherwise G1 = 0 if

$$PTg < PT\ l \qquad (4)$$

then battery is discharged to supply extra load that is not available to renewable s by triggering discharging controller by giving signal G2 = 1 if SOC of battery is greater than 0.5 otherwise G2 = 0. if

$$SOC < 0.5 \qquad (5)$$

then check PG to supply extra load, if

$$PG > 0 \qquad (6)$$

then give signal G3 = 1 otherwise give signal G3 = 0, when grid is fail to supply extra load, then it will switch off some controllable load by giving signal G4 = 0 otherwise G4 = 1. The voltage injected from series inverter either may be positive (real power absorbed) or negative(real power supplied) is depends on magnitude between reference voltage and actual voltage.

I. NSGA-II algorithm

Non-dominated Sorting Genetic Algorithm, Non-dominated Sorting Genetic Algorithm, Fast Elitist Non-dominated Sorting Genetic Algorithm, NSGA, NSGA-II, NSGAII.

Taxonomy: The non-ruled sorting genetic algorithm is a multiple goal optimization (moo) algorithm and is an example of an evolutionary set of rules from the field of evolutionary computation. Discuss with for greater records and references on more than one goal optimization. NSGA is an extension of the Genetic Algorithm for multiple objective function optimizations. It is related to other Evolutionary Multiple Objective Optimization Algorithms (EMOO) (or Multiple Objective Evolutionary Algorithms MOEA) such as the Vector-Evaluated Genetic Algorithm (VEGA), Strength Pareto Evolutionary Algorithm (SPEA), and Pareto Archived Evolution Strategy (PAES). There are variations of the algorithm, the classical nsga and the updated and presently canonical form NSGA-II.

Method: The goal of the nsga algorithm is to improve the adaptive suit of a population of candidate solutions to a Pareto the front confined with the aid of a hard and fast of objective functions. The algorithm uses an evolutionary manner with surrogates for evolutionary operators together with selection, genetic crossover, and genetic mutation. The population is sorted into a hierarchy of sub-populations based on the ordering of Pareto dominance. Similarity between members of each sub-group is evaluated on the Pareto front, and the resulting groups and similarity measures are used to promote a diverse front of non-dominated solutions.

Procedure: Algorithm (beneath) provides a pseudo code listing of the non-dominated sorting genetic set of rules ii (NSGA-II) for minimizing a price function. The sort with the aid of rank and distance function orders the populace into a hierarchy of non-dominated pareto fronts. The Crowding Distance Assignment calculates the average distance between members of each front on the front itself. Refer to Deb et al. for a clear presentation of the Pseudo code and explanation of these functions. The CrossoverAndMutation function performs the classical crossover and mutation genetic operators of the Genetic Algorithm. Both the select parents by rank and distance and sort by rank and distance features discriminate members of the population first by using rank (order of ruled priority of the front to which the solution belongs) and then distance in the front (calculated by crowding distance project).

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VIII. SIMULATION RESULTS

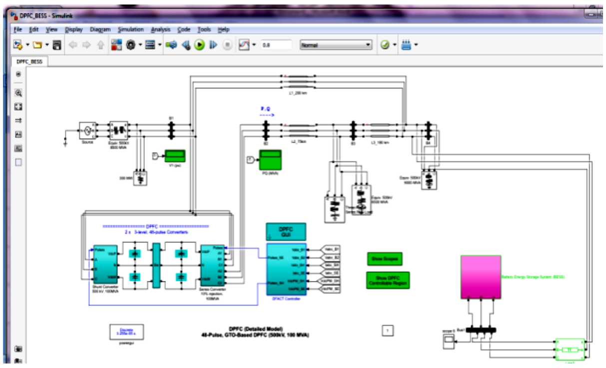

Fig.4 Simulation model of the system

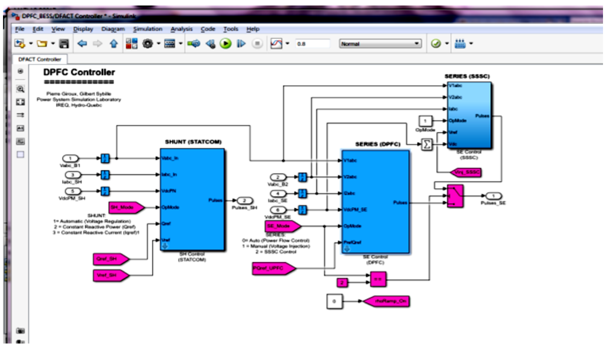

Fig.5 DPFC controller

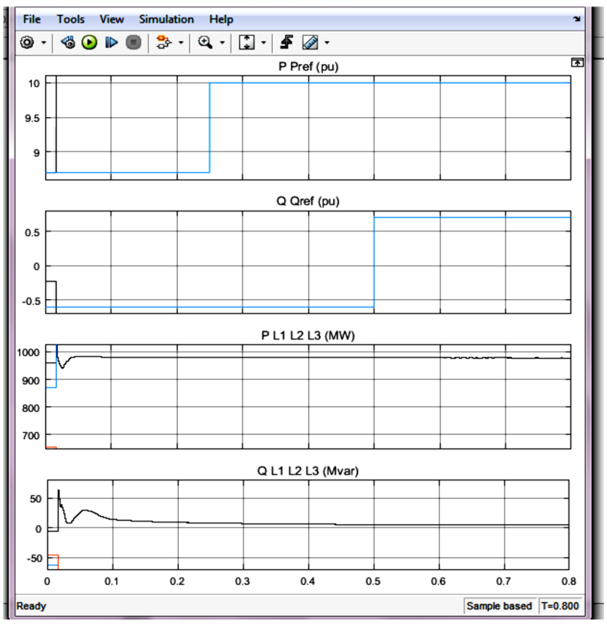

Fig.6 Signal parameter of the DPFC

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IX. CONCLUSION

The integration of dc-microgrid with both Energy Management System and DPFC will improve the performance of Microgrid. Overall cost of microgrid operation can be reducing by using EMS. EMS leads to better utilization of manpower, non-breakdowns in the system, savings in the energy consumption etc. Energy management controller is developed to control the gate signal of switches that are connected at source and load side. To mitigate LV side disturbances DPFC is used to provide good power quality control. DPFC is able to mitigate supply side disturbance by using its series converter and load side disturbance through shunt converter. EMS along with DPFC helps us to get benefits of both systems. The proposed system yields better results than using each system individually. Results shows that proposed system gives better results for energy management of dc-microgrid based on availability of total generation, battery SOC and depending on it EMS gives result to connect and disconnect total controllable load also UPQC connected across non controllable load mitigate power quality issue like Voltage sag/dip, current sag. Integration EMS with DPFC gives better energy management with better power quality control.

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